Atomic Fine-Structure Diagnostic and Cooling Transitions for Far Infraredand Submillimeter Observations

Completed Technology Project (2014 - 2018)

Project Introduction

Some of the strongest emission lines observed from a variety of astronomical sources originate from transitions between fine-structure levels in the ground term of neutral atoms and lowly-charged ions. These fine-structure levels are populated due to collisions with e-, H+, H, He, and/or H_2 depending on the temperature and ionization fraction of the environment. As fine-structure excitation measurements are rare, modeling applications depend on theoretically determined rate coefficients. However, for many ions electron collision studies have not been performed for a decade or more, while over that time period the theoretical/computational methodology has significantly advanced. For heavy-particle collisions, very few systems have been studied. As a result, most models rely on estimates or on low-quality collisional data for fine-structure excitation. To significantly advance the state of fine-structure data for astrophysical models, we propose a collaborative effort in electron collisions, heavy-particle collisions, and quantum chemistry. Using the R-matrix method, fine-structure excitation due to electron collisions will be investigated for C, O, Ne^+, Ne^{2+}, Ar^+, Ar^{2+}, Fe, Fe^+, and Fe^{2+}. Fine-structure excitation due to heavy-particle collisions will be studied with a fully quantum molecular-orbital approach using potential energy surfaces computed with a multireference configuration-interaction method. The systems to be studied include: C/H^+, C/H_2, O/H^+, O/H_2, Ne^+/H, Ne^+/H_2, Ne^{2+}/H, Ne^{2+}/H_2, Fe/H^+, Fe^+/H, and Fe^{2+}/H. 2D rigid-rotor surfaces will be constructed for H_2 collisions, internuclear distance dependent spin-orbit coupling will be computed in some cases, and all rate coefficients will be obtained for the temperature range 10-2000 K. The availability the proposed fine-structure excitation data will lead to deeper examination and understanding of the properties of many astrophysical environments, including young stellar objects, protoplanetary disks, planetary nebulae, photodissociation regions, active galactic nuclei, and x-ray dominated regions, hence elevating the scientific return from current (SOFIA, Spitzer, Herschel, HST) and upcoming (JWST) NASA IR/Submm astrophysics missions, as well as from ground-based telescopes.

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Organizational Responsibility

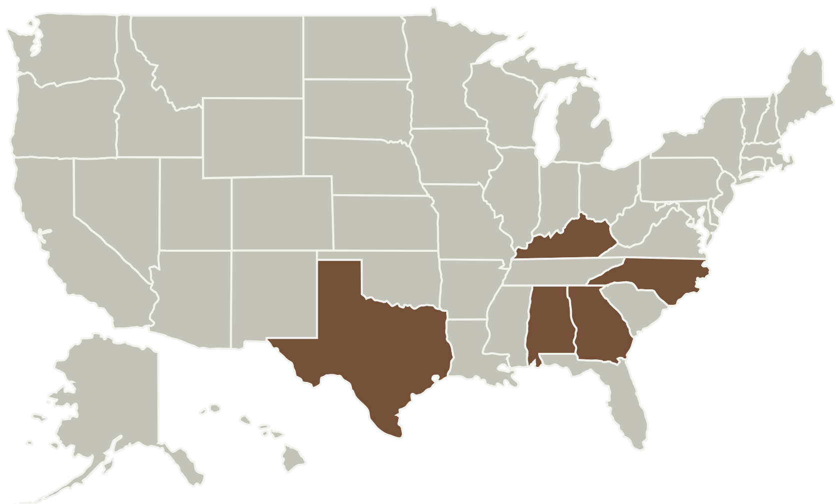
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Auburn University	Supporting Organization	Academia	Auburn, Alabama

Primary U.S. Work Locations	
Alabama	Georgia
Kentucky	North Carolina
Texas	

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Connor P Ballance

Co-Investigators:

Phillip C Stancil
Michael S Pindzola
Gary J Ferland
Robert J Buenker
David R Schultz

Technology Areas

Primary:

- TX17 Guidance, Navigation, and Control (GN&C)
  └ TX17.5 GN&C Systems Engineering Technologies
    └ TX17.5.2 GN&C Fault Management / Fault Tolerance / Autonomy

Target Destination

Outside the Solar System